

MICROSTRUCTURES OF RARE SILICATE STARDUST FROM NOVA AND SUPERNOVAE.

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Introduction: Most silicate stardust analyzed in the laboratory and observed around stellar environments derives from O-rich red giant and AGB stars [1,2]. Supernova (SN) silicates and oxides are comparatively rare, and fewer than 10 grains from nova or binary star systems have been identified to date. Very little is known about dust formation in these stellar environments. Mineralogical studies of only three O-rich SN [3-5] and no nova grains have been performed. Here we report the microstructure and chemical makeup of two SN silicates and one nova grain.

Experimental: Silicate grains having exotic O isotopic compositions were identified amongst matrix grains of the Acfer 094 meteorite by NanoSIMS O and Si isotopic imaging. Grains having unusual isotopic signatures were then measured for Mg, and in some cases Fe, isotopes after removal of surrounding grains by focused ion beam milling [6]. Cross-sections were then produced for three of these presolar silicates and their microstructures were determined by transmission electron microscopy (TEM).

Results and Discussion: *Supernova silicates.* Two silicates had O and Mg isotopic ratios consistent with condensation in 15M_⊙ SNe. Grain 6_16 is enriched in ¹⁸O (1.5×solar) and slightly depleted in ²⁵Mg. Si and Fe isotopic ratios are solar within error. This grain is amorphous and has a chemical composition consistent with Mg-rich olivine (Fo95). Grain 2_33b is anomalous in both O and Mg ($\delta^{17}\text{O}=355\text{‰}$, $\delta^{18}\text{O}=700\text{‰}$, $\delta^{25}\text{Mg}=-250\text{‰}$, $\delta^{26}\text{Mg}=130\text{‰}$), but not Si. Little grain material remained after the NanoSIMS analyses, but TEM analysis indicated an amorphous Fe-rich silicate with minor Mg and Ca and nanophase FeNi metal inclusions. This structure is reminiscent of glass with embedded metal and sulfides (GEMS) [7], though beam damage cannot be excluded. While presolar GEMS have been identified in interplanetary dust particles [8], conclusive identification of these grains in meteorite samples has not been made.

The mineralogies of two other SN silicates have previously been determined: B10A is an aggregate of crystalline olivine (Fo83) [3] and 2_4 is amorphous MgSiO₃ [5]. The chemical compositions of B10A, 2_4 and 6_16 suggest equilibrium condensation. In contrast to other SN dust phases, the SN silicates have varied mineralogies and are mostly amorphous, though alteration from an initially crystalline state cannot be ruled out.

Nova silicate. Silicate 4_2 was found to be highly ¹⁷O-rich and also anomalous in ¹⁸O and Mg isotopes ($\delta^{17}\text{O}=32410\text{‰}$, $\delta^{18}\text{O}=-130\text{‰}$, $\delta^{25}\text{Mg}=1025\text{‰}$, $\delta^{26}\text{Mg}=90\text{‰}$), suggestive of a nova source (see [6]). An extremely limited amount of material remained for TEM analysis, but the silicate contains Al (Al/Si=0.3) and some Fe, likely contamination from an underlying Fe oxide grain. Nova grains are exceptionally rare and no other microstructural studies of O-rich nova dust exist to date. Identification of additional nova silicates is highly desirable.

References: [1] Nguyen A.N. et al. 2010. ApJ 719:166. [2] Waters L.B.F.M. et al. 1996. A&A 315:L361. [3] Messenger S. et al. 2005. Science 309:737. [4] Stroud R.M. et al. 2008. LPSC 39: #1778. [5] Nguyen A.N. et al. 2010. Met. Planet. Sci. 45:A5423. [6] Nguyen A.N. et al. 2011. LPSC 42: #2711. [7] Bradley J.P. and Dai Z.R. 2004. ApJ 617:650. [8] Keller L.P. and Messenger S. 2011. GCA, in revision.